ROPE CLIMBING ROBOT

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“I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)

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ABSTRACT

This project is all about developing a rope climbing robot which prioritizes in only one task of manipulating its position on a rope. The robot is assigned to perform climbing motions on a vertical rope in a limited amount of time. The objective here is to produce an efficient, low powered and cost effective self climbing robot that is able to reach the top of the rope in the least amount of time. All the power sources are on-board and the robot will be totally mobile (no cords or wires attached from circuits other then on board). The climber robot can be attached with external circuits to serve various tasks such as by fixing a small video camera to offer "visual access" in places where access by human presence is difficult and dangerous

ABSTRAK

Objektif utama projek ini adalah untuk menghasilkan sebuah robot yang memanjat tali, yang mengutamakan tugasnya iaitu memanipulasi kedudukannya pada tali. Robot ini ditugaskan untuk melakukan gerakan memanjat pada tali menegak dalam masa yang ditentukan. Tujuannya di sini adalah untuk menghasilkan sebuah robot yang cekap, menggunakan kos yang rendah serta menggunakan kuasa yang rendah yang mampu mencapai puncak tali dalam masa yang paling singkat. Semua bekalan kuasa akan diletakkan pada robot itu sendiri yang menjadikan robot itu mobile (tidak ada tali atau kabel yang disambung dari litar litar luar). Robot ini boleh diaplikasi dengan litar luar untuk melaksanakan pelbagai tugas lain, antaranya ialah dengan menyambungkan kamera video untuk memberikan "akses visual" pada keadaan di mana kewujudan manusia sukar dan mendatangkan bahaya.

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LIST OF ABBREVIATIONS

RCR	Rope Climbing Robot
DC	Direct Current
CAD	Computer Aided Design
CPU	Central Processing Unit
GUI	Graphical User Interface

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CHAPTER I

INTRODUCTION

1.1 Overview Of Mobile Robots (Rope Climbing Robot)

The increased attention given to the problems on safety and health in the work place has raised the demand on mobile inspections robots. The safety of human operators in hazardous industrial environment have always been the main concern which then resulted in implementation of mobile robots for several inspection purposes. Conventional mobile robots are normally large in size depending on the task the machine has to endure. With bigger size, comes a substantial amount of weight which then results to a significant rise on the force needed to be mobile or to move. In this case, bigger actuators (motors) consuming more power and the locomotion or the movement of the robot generally becomes slower. Large mobile robots are normally attached to an external power source whether is pneumatic, hydraulic or electrical power source. The plan here is to surpass all these weakness or element that prevents the full efficiency of a rope climbing robot. To achieve this, few important points have been chosen in this paper to be examined and modified for better performance. Some parts of it have to be implemented with new sources to give it the edge of performance. Through this project a light weight, fast, low power consuming and a cost effective rope climbing robot (RCR) is to be produced.

1.2 Objectives

i. To design and simulate the mechanical body of the robot using the SOLIDWORK software.

ii. To successfully program a 8051(89C51) microcontroller to control motor and solenoids to enable the robots climbing movement in the fastest time.

iii. To successfully design and develop a rope climbing robot (RCR) which performs the task of achieving climbing motion in the shortest amount of time.

1.3 Scope Of Project

i. To design and simulate the mechanical body of the robot using the SOLIDWORK software. The body of the robot will consist of 2 sets of grippers to grip the rope, the motor railing(including the gearing) to push and pull the lower part of the two part body which will generate the climbing motion and the other parts of the body for stability of the robot when the climbing task is being performed. These designs will be done using

SOLIDWORKS 2009 where each part of the robot will be design separately and then mated in a 3D drawing.

ii. To develop a controller circuit to power and manipulate the motors and solenoid by programming an 8051(89c51) micro controller with a program which would achieve the climbing motions the fastest. This program would be subjective. It would be changed and modified to meet the task of manipulating the robot's position on a rope. After the integration of mechanical and electrical parts, the program would be further changed to meet the limitation of the constructed robot's body.

iii. To successfully design and develop a rope climbing robot (RCR) which performs the task of achieving climbing motion in the shortest amount of time. Here the time taken to climb a rope is taken into account. To achieve this, a solid integration between the electrical and mechanical element should be optimized. This means that the electrical circuit would be constructed based on the limitation of the mechanical body.

1.4 Problem Statement

Mobile robots are special robots with selected function tasks. The design and construction a mobile robot, in this case the rope climbing robot must be plotted or planned based on the specification to perform the selected tasks. The rope climbing robot (RCR) is constructed with few crucial components or parts of the hardware to suit it climbing operation. The elements on the RCR which should be taken into serious consideration are the grippers, the movement of the body, the microcontroller used for control the power source and the size of the whole body. The problem here is to match the capability of the drive system (motor) to the weight of the robot. This robot is also needed to be designed according to the Malaysian University Robot Competitions

(MURoC) themes and rules. The dimensions of the Rope Climbing Robot shall not exceed 250 mm (long) x 250 mm (wide) x 250 mm (tall). The robot also cannot be expanded more than the dimension provided. The application of roller or wheel as a based mechanism to climb the rope is extremely banned. Finally, the weight of the robot must not exceed 5kg. Other rules and regulations will be explained further in chapter 3. The main concern on mobile robots is the efficiency in terms of weight to speed ratio and speed to power consumption ratio. These are the problem which will be tackled in this project.

1.5 Project Flow

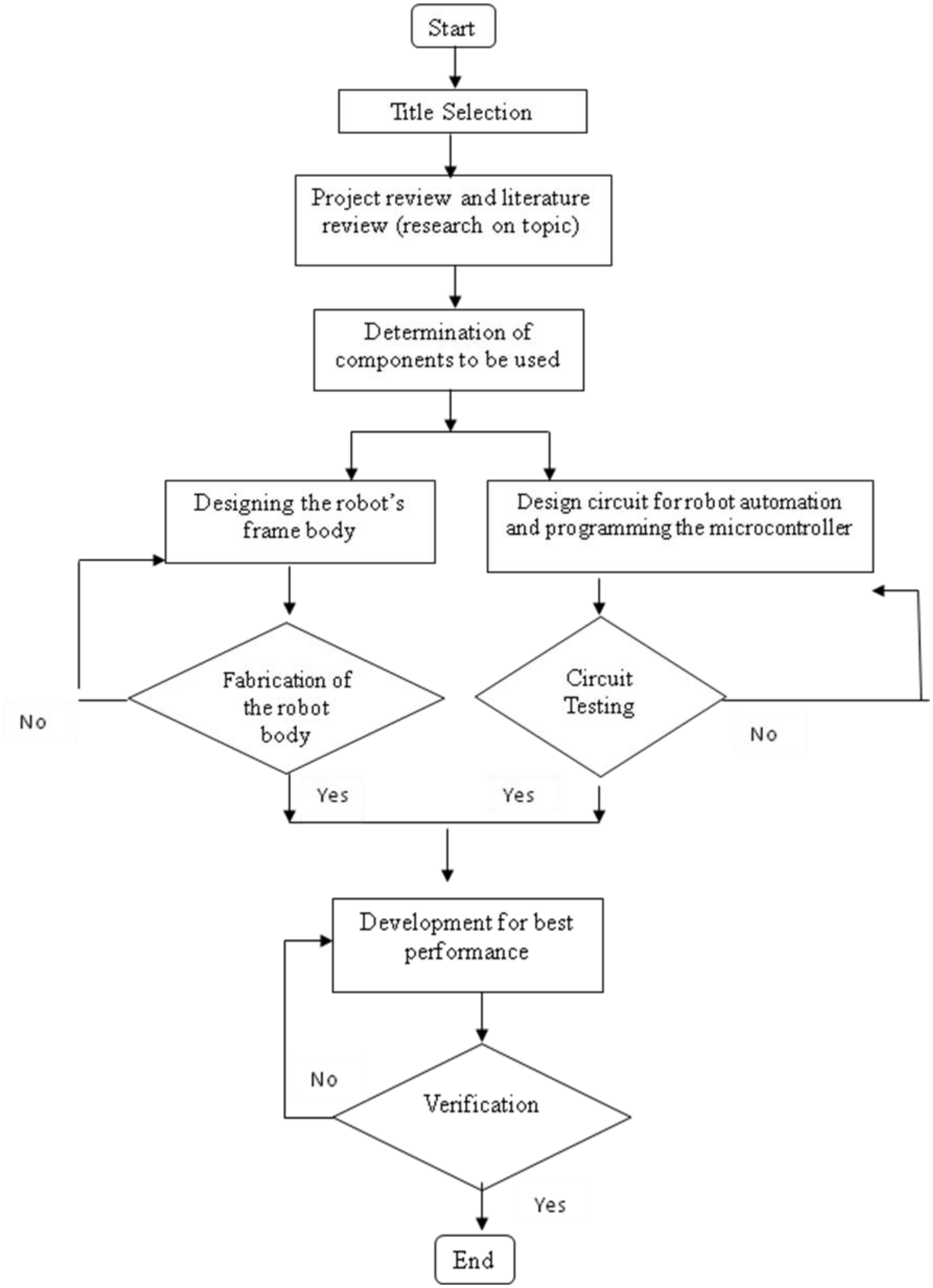

Figure 1.1 Project flowchart

CHAPTER II

LITERATURE REVIEW

2.1 Rope Climbing Robots

Rope climbing robots are mobile robots that are already in use nowadays. The Robotic industries increased the attention given to problems of safety and health in the work-place. The environments dangerous for human operators have also been identified which have delineated the characteristics of robots that can operate intelligently in hostile environments. Many researchers have come out with new type of mobile robots. These robots are used for inspection, surveillance, assistive works, search and rescue and many more

The first paper found regarding this RCR (Rope Climbing Robot) robot project was a paper explaining about *developing and employing special robots for inspections in construction in order to assist the human operator as well as to limit the damage caused to him* [1]. For this end, the ROMA robot, a specially developed self-supported robot has been built. The robot is designed to perform 30 complex movements and navigate through metallic structures using the “caterpillar” concept. The control and monitoring of the robot is achieved through an advanced Graphical User Interface, especially built, to allow an effective and user friendly operation of the robot with a minimum operator training. The GUI has been designed with an open and modular structure allowing future reusability and scalability when necessary. This paper in detail describes the design of the ROMA robot with a special emphasis on its GUI.

This paper also explains that ROMA robot consists of three essential parts: the body of the robot, the locomotion system and the sensorial platform. The body of the robot includes the CPU, the servo multi-axis controller board (PMAC) which comes with its own low level programming language, one servo motor amplifier (driver), the batteries, the radio-based Ethernet communication with the “ground” operation centre, three multiplexing systems and other auxiliary electronics[1] .

The difference between this the ROMA robot and the RCR robot that is to be accomplish in this project is, first, the rope climbing robot is much simple and involves less cost. The locomotion of the ROMA robot is formed by two grippers are attached to the robot body and driven by AC brushless servo motors through Harmonic Drive redactors, which permit the 3D movements along complex structures. While the movement of the RCR is based on a servo motor controlling the bottom half body of the robot motion up and down and gripping using two solenoid grippers.

The next paper that has been found regarding this project is the Sky Cleaner 3. In this article, the emphasis for discussion is on the wall cleaning robot for high-rise buildings. *Due to a current lack of uniform building structure, wall cleaning and maintenance of high-rise buildings is becoming one of the most appropriate fields for robotization* [2]. *The Sky Cleaner 3 is a real product designed for cleaning the complicated curve of the*

Shanghai Science and Technology Museum [2]. The robotic system consists of three parts, a following unit, a supporting vehicle and the cleaning robot. The cleaning robot is supported from above by cables from the following unit mounted on the top of the building. A hose for water, a trachea for pressurized air, and cables for control signals are provided from the supporting vehicle on the ground. The GUI is also installed on this vehicle. On the other hand, the following cables carry some of the weight of the hose and trachea when the robot is in midair. This is some of the information the paper provides.

The Sky Cleaner 3 uses a cable to suspend in the air. This is the same concept used in RCR robot, except that RCR uses a rope to climb and ascend. The main concern of the Sky Cleaner robot is the mobility of the robot. Although the robot is able to move sideways, but it is still limited to the length of the suspending cable and the length of the pneumatic hose for power. Compared to the RCR robot, mobility is not a problem as it is not attached to any auxiliary power. Its power pack (NiCad battery pack) is carried along with the robot.

A paper on the modular climbing robots was also found. This paper discusses about the task of traversing terrain by climbing, and presents various methods of climbing with modular robots. *In particular, the paper also focuses on the tasks of climbing across a horizontal rope, climbing up a vertical rope, and climbing up stairs using the Superbot modular robot* [3]. Locomotion is an interesting challenge in modular robotics as it involves the interconnection of several modules to overcome limitations of a single module such as power, size, torque and actuation precision. Wheels, tracks, paddles, legs and arms can be formed with modular robots enabling a large number of gaits for traversing diverse terrain. This paper presents a robot for rope climbing demonstrated on the Superbot modular reconfigurable robot. The robot has an inchworm type movement. The primary considerations in a rope-climbing action are the gripping attachments used to traverse the rope and how to deal with changes in rope tension. The inchworm robot essentially works by alternating gripping between each connector and sliding the other end along the rope in the desired direction. Much of the attention in developing the rope climbing action was on getting the attachments to grip and release at the appropriate times and consistently.

There was also a website on a modular climbing robot called SLOTH. SLOTH is a robot that is used for rope climbing. *Studying the anatomy and movement of a real biological sloth animal has inspired SLOTH's mechanical design and it's climbing gaits* [4]. SLOTH robot is constructed by three small servos and is controlled through an SSC II serial servo controller. SLOTH robot can be used as a telepresence robotic system by carrying a small video camera to offer "visual access" in places where access by human presence is difficult and dangerous. The robot's brain is based on the SSC II serial servo controller. The controller is connected through an RS-232 connection with a personal computer that runs the robot's Control Panel software. The robot uses only three servos. The first two servos used for the up and down grippers and the third for the body.

2.2 DC Motor With Built In Gearing

DC motors provide excellent speed control for acceleration and deceleration with effective and simple torque control. The fact that the power supply of a DC motor connects directly to the field of the motor allows for precise voltage control, which is necessary with speed and torque control applications. *A simple motor has six parts, Armature or rotor, Commutator, Brushes, Axle, Field magnet, and DC power supply of some sort* [5]. The brushes act as contacts between an external power source and the commutator. The design of these carbon brushes allows them to move up and down on a brush holder, to compensate for the irregularities of the commutator surface. Thus they are said to ride the commutator. The commutator regulates current flow in the armature coils, allowing it to flow in one direction only. Each segment of the commutator is directly connected to an armature coil, so the commutator rotates with the armature. In this project the DC motors used is a 5 Volt built in gearing model. This enables the motor to drive a large load.

Figure 2.1 The standard DC motor with gearing

2.3 ATMEL 8051 Microcontroller

A microcontroller is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory. Microcontrollers are designed for small or dedicated applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. *A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used with an embedded*